AN3273
Application note

STEVAL-IPP001V2: E-meter PLM demonstration board

Introduction

The purpose of this application note is to describe the use of the E-meter PLM demonstration board both in standalone and network mode. The E-meter demonstration board can be used as a guideline to design a typical energy-meter board for smart metering applications.

The document describes how to configure the board and how to interact with it; buttons, LEDs, configuration jumpers, and all hardware components used are described in detail, as well as the meaning of LCD data. A full description of the power line communication and its configuration and commands is provided too.

The E-meter demonstration board is based on the STM32F103VE microcontroller, ST7580 PLM module, and the STPMC1 poly-phase energy metering IC. It implements a PLM smart-meter node which allows the final utility to monitor energy consumption and other electrical parameters on one or more phases.

The voltage, current, power, power factor, THD, active and reactive energy, and other stored info can be shown on an LCD locally, or sent to a PLM data concentrator through a power line communication network.

- *Section 1* describes document and library rules
- *Section 2* describes the smart E-meter hardware demonstration board, its modes, uses and limitations
- *Section 3* highlights how to use the E-meter board in a PLC network and describes the PLM frames to be used in order to manage the board from another PLM node
- *Section 4* shows board schematics and the BOM list. Refer to UM0997 for more hardware details.

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1 Document and library rules

This document uses the conventions described in the sections below.

1.1 Acronyms

Table 1 lists the acronyms used in this document.

Table 1. List of acronyms

Acronym	Meaning
APP	Application
API	Application programming interface
HAL	Hardware abstraction layer
RTOS	Real-time operating system
PLM	Power line modem
PLC	Power line communication
MCU	Microcontroller unit
SPI	Serial peripheral interface
OOP	Object oriented programming

2 E-meter PLM demonstration board

2.1 Board introduction

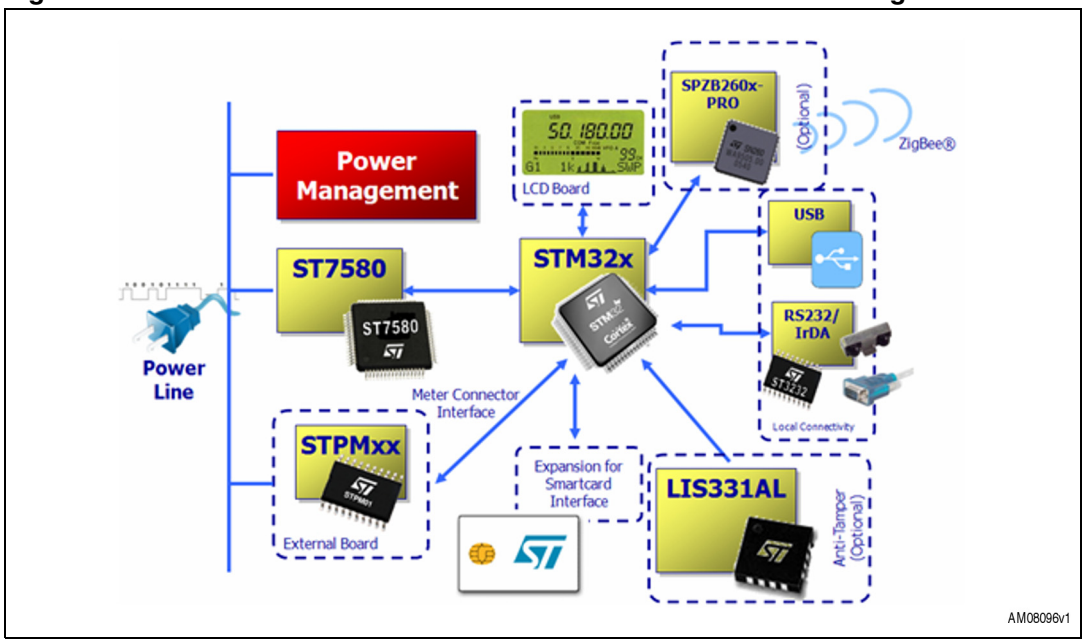
The application described in this document refers to the STEVAL-IPP001V2 demonstration board (see related UM0997 user manual).

Figure 1. STEVAL-IPP001V2 E-meter PLM demonstration board

The E-meter demonstration board can be used as a guideline to design a typical energy-meter board for smart metering applications. It was designed to include advanced features as well as to fit the requirements for next generation energy-meters. These extra features can be added to the board by modules for easy customizing. The board includes the following functions shown in the block diagram of *Figure 2*:

- Energy measurement by external metrology board
- Power line communication up to 28.8 kbps
- LCD display to show energy consumption information
- USB and RS232/IrDA connectivity
- Optional ZigBee® communication capability
- Optional MEMS module support
- Expansion capability for smartcard interface.

Figure 2. STEVAL-IPP001V2 E-meter demonstration board block diagram



Warning: **The board must be used only by expert technicians. Due to the high voltage (220 Vac) special care should be taken with regard to user safety. There is no protection against accidental human contact with a high voltage. After disconnection of the board from the mains, none of the live parts should be touched immediately because of the energized capacitors. It is mandatory to use a mains insulation transformer to perform any debugging/tests on the board in which debugging and test instruments such as USB-JTAG dongles, spectrum analyzers, or oscilloscopes are used. Do not connect any oscilloscope probes to high voltage sections in order to avoid damaging instruments and demonstration tools.**
ST assumes no responsibility for any consequences which may result from the improper use of this tool.

2.2 Main hardware components

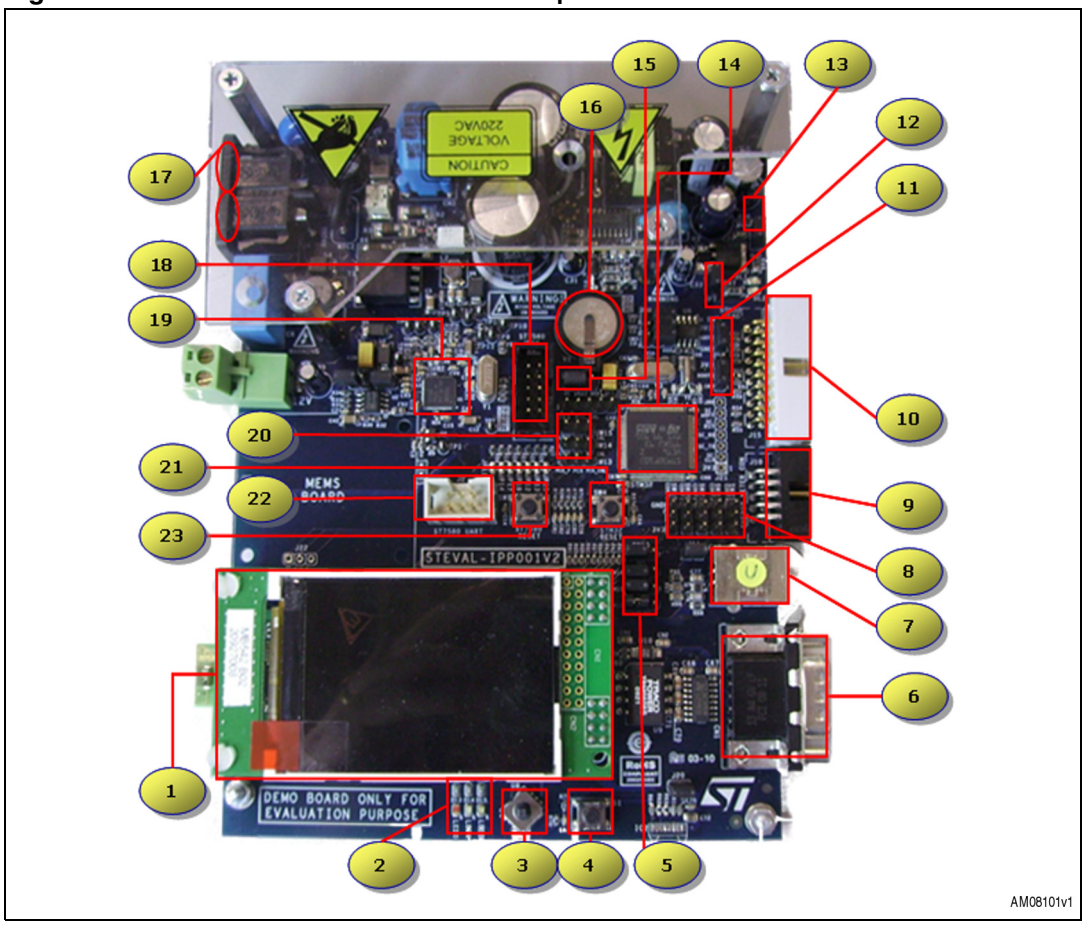
The E-meter demonstration board main hardware components are:

- An STM32F103VE microcontroller running the application firmware
- An external STPMC1 multiphase energy metering IC; the external STEVAL-IPE010V1 demonstration board based on STPMC1 has been used in this firmware release
- An MB542B-01 320x240 color TFT LCD module; used to show data locally
- An ST7580 power line modem; used to provide PLC connectivity to the system
- 3 status LEDs; 1 green, 1 yellow, 1 red LED for application status scope

- 5 configuration jumpers (SW19, 20, 21, 22, and 23); used for software configuration scope
- 1 user button (S1) and 1 joystick (U8); used for user application scope
- 1 microcontroller reset button (SW4); used to force an MCU reset
- 1 modem reset button (SW1); used to force an ST7580 reset.

A general description of the E-meter PLM demonstration board is provided in *Figure 3*:

Figure 3. STEVAL-IPP001V2 hardware description



1. TFT LCD color display 320x240
2. General purpose application red, green, yellow LEDs
3. General purpose application joystick; switch meter user data
4. General purpose user application button; switch the phase view on LCD from 3, R, S, T
5. Energy-meter configuration jumper (SW10) to use SPI-MISO or SPI-MOSI for data line LCD configuration jumpers (SW16, SW17, SW18) to control LCD via SPI or GPIO
6. RS232 USART connector
7. USB connector
8. General purpose application configuration jumpers (SW19, SW20, SW21, SW22, SW23)
9. Energy-meter external board connector (e.g. IPE010V1)
10. STM32 JTAG 20-pin connector

11. STM32 boot configuration jumpers (SW7, SW9)
12. Enable/disable DL2 LED
13. Enable/disable DL1 LED
14. STM32F103VE 32-bit high density microcontroller
15. Battery enabled/disabled configuration jumper (SW12)
16. Battery for STM32 VBAT supply
17. 85 V - 256 V board power supply. Suggested 110 V - 220 Vac
18. ST7580 JTAG 10-pin connector
19. ST7580 power line modem IC
20. RTC calibration/normal mode configuration jumpers
21. STM32 microcontroller reset button
22. ST7580 PLM IC UART connection connector
23. ST7580 PLM IC reset button.

2.3 Power-on and board use

Before turning on the board for the first time, make sure the following configuration jumpers are fitted or unfitted according to the following default table:

Table 2. Jumpers default configuration

Jumper	Description	Default
JP6	DL1 enable – Fitted: DL1 enabled – Not fitted: DL1 disabled	Fitted
JP7	DL2 enable – Fitted: DL2 enabled – Not Fitted: DL2 disabled	Fitted
JP8	To connect mains ground to board ground – Fitted: grounds connected – Not fitted: grounds not connected	Not fitted
SW3, SW5, SW6	EEPROM address setting – Fitted (1-2): address bit 1 – Fitted (2-3): address bit 0	Fitted (2-3)
SW7, SW9	Boot option – Fitted (1-2): boot option bit 0 – Fitted (2-3): boot option bit 1	Fitted (1-2)
SW12	STM32 VBAT option – Fitted (1-2): VBAT from power supply – Fitted (2-3): VBAT from battery ß	Fitted (1-2)
SW13, SW14, SW15	RTC calibration mode – Fitted (1-2): normal mode – Fitted (2-3): RTC calibration mode	Fitted (1-2)

Table 2. Jumpers default configuration (continued)

Jumper	Description	Default
SW19, SW20, SW21, SW22 SW23	General purpose configuration bit – Fitted (1-2): configuration bit 0 – Fitted (2-3): configuration bit 1	Fitted (1-2)
JP11, JP12, JP13, JP14, JP15, JP17, JP18	STM32-ST7580 connection – Fitted: STM32-ST7580 control lines connected – Not fitted: STM32-ST7580 control lines not connected	Fitted
J11	Energy-meter board power supply option – Fitted: energy-meter powered by the board – Not fitted: energy-meter self powered	Fitted
SW10	Energy-meter data line option – Fitted (1-2): data line connected to SPI2-MOSI – Fitted (2-3): data line connected to SPI2-MISO	Fitted (2-3)
SW16, SW17, SW18	LCD connection option – Fitted (1-2): LCD controlled by SP1 – Fitted (2-3): LCD controlled by GPIOs	Fitted (1-2)
JP5	ST7580 external flash enable – Fitted: ST7580 run flash firmware – Not fitted: ST7580 disabled	Fitted
JP4	ST7580 external flash hold – Fitted: flash data output disabled – Not fitted: flash data output enabled	Not fitted

Once configuration is set according to the above description, connect and cable the STEVAL-IPE010V1 poly-phase energy-meter demonstration board before powering on the smart E-meter board.

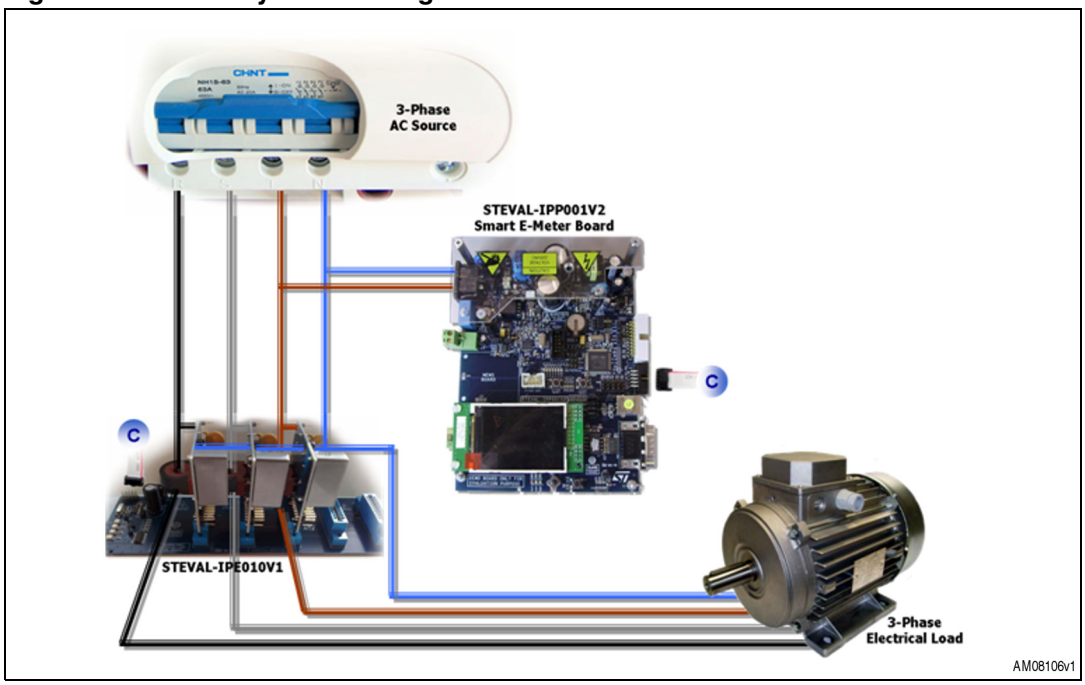
2.3.1 STEVAL-IPE010V1 energy-meter board use

The STEVAL-IPE010V1 must be calibrated. It means that STPMC1 OTP calibration registers have been calibrated in order to read coherent voltage, current, and energy data through the STPMS1 daughter boards connected to the board for each monitored phase.

Figure 4 shows the cabling-schema for the STEVAL-IPP001V2 plus STEVAL-IPE010V1 3-phase system.

It is also possible to cable the full system in mono-phase schema, using one daughter sensor board only (on top of STEVAL-IPE010V1) and configuring STPMC1 in order to work in mono-phase mode (see the STPMC1 datasheet).

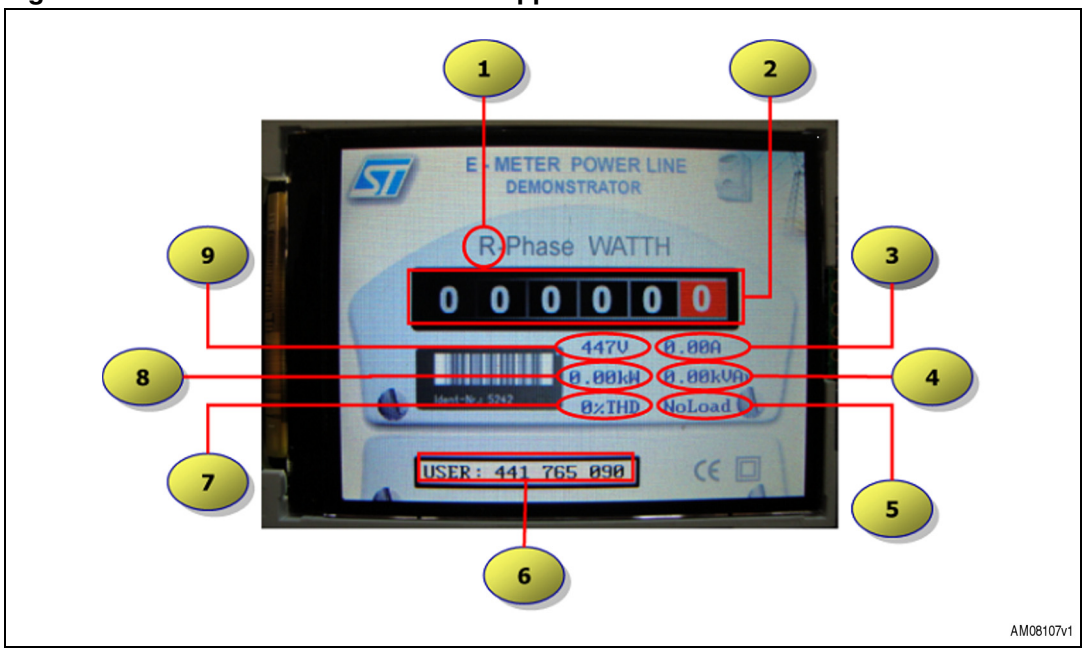
Figure 4. Phase system cabling schematic



2.3.2 E-meter application running

Once the 3-phase system is put in place, according to the previous description, the system is powered on, the smart E-meter application shows the following view on the LCD:

Figure 5. STEVAL-IPP001V2 E-meter application view



1. Phase identification (3, R, S, T)
2. Energy counter in watts. Red digit represents tenths of a watt
3. Phase current in ampere

4. Phase reactive energy in kVar
5. Power factor or “no load” if no load condition is detected
6. Meter user data; use joystick to move shown data
7. Phase THD parameter in percentage
8. Phase wide active power in kWatt
9. Phase voltage in Volts.

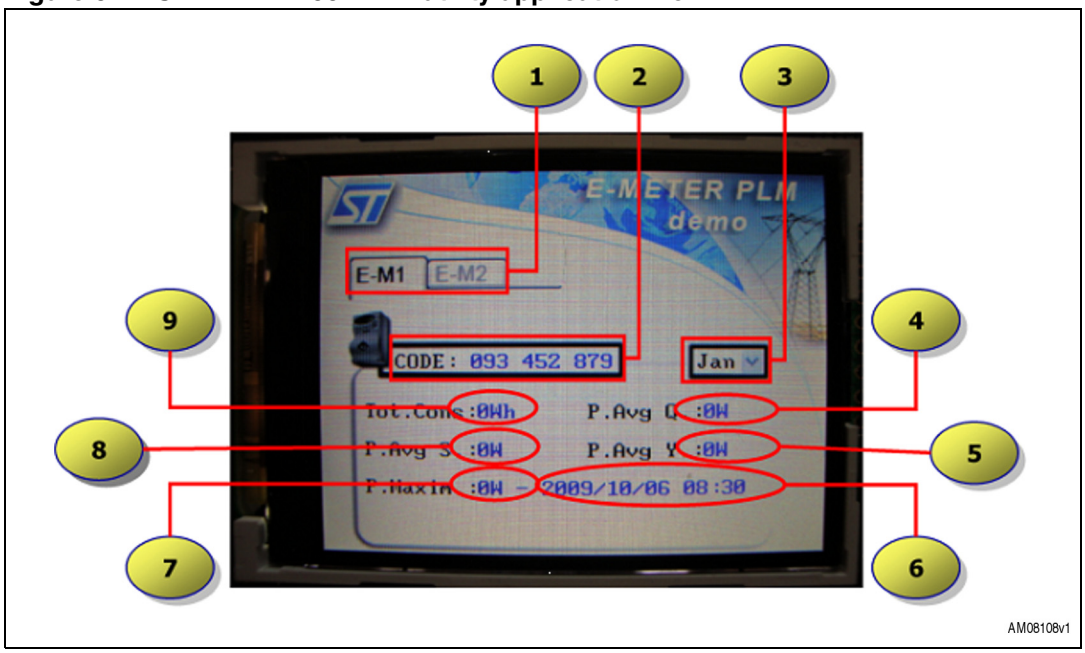
If the application is running without any problems a green LED (LED1) is blinking. During counter moving, the red LED (LED0) blinks every time the red number (tenths of a watt) moves to the next step.

To move from a phase view to the next phase view, it's necessary to press user button S1. Joystick U8 allows to scroll through user data.

2.3.3 E-utility application running

An E-utility application managing up to two smart E-meters has been implemented to test the smart-meter power line communication. The board used to run the E-utility application is the same STEVAL-IPP001V2 and after powering on the board, the E-utility application shows the following view (*Figure 6*) on the LCD:

Figure 6. STEVAL-IPP001V2 E-utility application view



1. Tablet used to switch the managed E-meter (up to two E-meters can be managed using the joystick)
2. E-meter identification code (also reported on the E-meter LCD view)
3. The selected month which asks the E-meter for data. Use the joystick button to change the month used in the request and use button S1 to send the request via PLM
4. Average power stored for last quarter

5. Average power stored for last year
6. Date and time
7. Maximum demand power for the selected month
8. Average power stored for last six months
9. Total energy consumption of the selected E-meter.

Joystick left/right keys are used to move from the first to the second managed meter; joystick key press is used to change the selected month; user button S1 is used to send a request to the selected E-meter.

2.4 Board and application limitations

The smart E-meter is for evaluation purposes only. The board and running applications have the following limitations:

- Smart E-meter application counter supposes to count active positive energy only. Even if STPMC1 is able to count negative energy, the application doesn't support this kind of energy in this release
- High voltage disturbance. Sometimes a high voltage disturbance, such as button line spike (and so a button action), is observed during turn on/off of the electric load connected to the smart E-Plug
- A 7-byte static address has been assigned via firmware to the smart E-meter application, as below. If it is necessary to use more than one smart E-Meter demonstration board in a demonstrator system, this address must be changed manually in order to differentiate STEVA-IPP001V2 boards:

```
#ifdef METER_1
   u8 DL_ADDRESS[7] = {0xAA, 0xBB, 0xCC, 0xDD, 0xEE, 0xFF, 0x0};
#else
   u8 DL_ADDRESS[7] = {0xAA, 0xBB, 0xCC, 0xDD, 0xEE, 0xF0, 0x0};
#endif.
```

In a future release a limited set of MAC addresses could be managed using the board configuration jumpers.

3 PLM network and frames

This section describes how to use the meter board inside a network with a master/slave architecture. The network includes several meters (slaves) and one data concentrator (master). Each meter maintains a database with the energy consumption data statistics which are stored in an external EEPROM. The master can read the statistics data of each meter, requesting them through commands transferred using the PLM communication.

3.1 PLM Network parameters

During startup each node configures the physical layer of the ST7580 with the following parameters:

Table 3. PHY layer configuration

General settings 1	0x11
Frequency pair	72-86 kHz
TX channel	High channel
Rx channel	Only high channel
Zero-crossing synchronization	Asynchronous
Current control	Enabled
General settings 2	0x15
TX modulation	BPSK
TX gain	21
General settings 3	0x0E
RX high channel modulation	Any PSK
RX low channel modulation	Any PSK
PSK preamble length	32 bits
FSK modulation settings	0x3A
Baud rate	2400 bps
Deviation	1
Preamble length	32 bits
Unique word length	16 bits
FSK modulation unique word LSB	0x9B
FSK modulation unique word MSB	0x58

The master address is configured as AA-BB-CC-DD-EE-00 in hexadecimal format. For a complete list of the possible modem settings refer to the ST7580 data brief.

3.2 Smart E-meter use inside a PLM network

A demo application layer for metering applications has been implemented on top of the PLM communication protocol. The layer implements a command/response protocol with three kinds of frames:

Table 4. Command set

Command name	Code	Description
GET	0x00	Command to read database variable of the remote meter
SET	0x01	Command to write database variable of the remote meter
RSP	0x02	Response to a GET request

The database variables are identified by the classes described in *Table 5*. The same table shows how some classes have sub-classes and also the access permission.

Table 5. Class set

Class name	Class code	Sub-class name	Sub-class code	Description
TOTAL_CONS	0x00	N/A	N/A	Total energy consumption variable (read only)
AV_MD	0x01	N/A	N/A	Average maximum demand variables (read only)
TARIFF_LIST	0x02	TARIFF_NUM	0x00	Number of tariff managed by the meter (read/write)
		TARIFF	0x01	Tariff variable (read/write)
TAMPER_LIST	0x03	N/A	N/A	List of detected tamper by the meter (read only)
MD_DB	0x04	DAY	0x00	Daily based maximum demand variable
		MONTH	0x01	Monthly based maximum demand variable
		QUARTER	0x02	Quarter based maximum demand variable
MD_CONFIG	0x05	N/A	N/A	Maximum demand storage configuration (read/write)
DEMO	0x06	N/A	N/A	Command class used in the demo application

Figure 7 summarizes the generic application layer frame format and also the format for each command.

Figure 7. Commands format summary

SET/GET (1 byte)	CLS (1 byte)	PAYLOAD			
GET	TOTAL_CONS	null (0 bytes)			
GET	AV_MD	null (0 bytes)			
SET/GET	TARIFF_LIST	TARIFF_NUM	value (1 byte)[1]		
		TARIFF	index (1 byte)	Tariff (sizeof(TARIFF_T)) [1]	
GET	TAMPER_LIST	index (1 byte)	tamper_info (sizeof(TAMPER_INFO_T))		
GET	MD_DB	DAY	month (1 byte)	day (1 byte)	value (sizeof(MD_T)) [1]
		MONTH	month (1 byte)	null(1 byte)	value (sizeof(MD_T)) [1]
		QUARTER	quarter (1 byte)	null(1 byte)	value (sizeof(MD_T)) [1]
SET/GET	MD_CONFIG	value (sizeof(MD_CONFIG_T))			
GET	DEMO	month (1 byte)	total_cons	av_md	md_db(month)

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The meter firmware is released with a monthly based configuration of the maximum demand and the master implements only the DEMO class command which allows the reading of the total consumption, the average maximum demand, and the maximum demand of the month specified by the month index. The data transferred have the following structures:

Table 6. Data structures

Variable	Structure format

Tariff	`typedef struct tariff {`
	`  float rate;`
	`  long long kwh;`
	`  u32 pulse_count;`
	`  DATE_T change_t;`
	`  u8 next;`
	`} TARIFF_T;`

Tamper info	`typedef struct {`
	`  CONS_T cons;`
	`  DATE_T f_tamp_box_date;`
	`  DATE_T l_tamp_box_date;`
	`  DATE_T f_tamp_fraud_date;`
	`  DATE_T l_tamp_fraud_date;`
	`  DATE_T tamper_time;`
	`  DATE_T fail_time;`
	`} TAMPER_INFO_T;`

Table 6. Data structures (continued)

Variable	Structure format
Maximum demand	typedef struct { MONTH_MD_DB_T DayStore; MD_T MonthStore[12]; MD_T QuarterStore[4]; }MD_DB_T;
Total consumption	typedef struct { long long kwh; u32 pulse_count; } CONS_T;
Average maximum demand	typedef struct { u32 last3; u32 second_last3; u32 third_last3; u32 fourth_last3; u32 last6; u32 last9; u32 last12; }AV_MD_T;

Maximum demand storage configuration	typedef struct {
	u32 period; //minutes
	MD_STORAGE_T storage;
	u32 sample_time; //mSec.
	} MD_CONFIG_T;

4 BOM list

Table 7. BOM

Reference	Part / value	Tolerance %	Voltage current	Watt	Technology information	Package-footprint	Manufacturer	Manufacturer code	RS/Distrelec/ other code	More info
CM3	IND-EPCOS-B82721K			Power line chokes 10 mH 0.7 A	Through hole	EPCOS	B82721K2701N020	Digi-Key: 495-2739-ND	Any	
CN1	PORT 0				R/A DB9 male connector (plug)	Through hole	Any		RS:542-8009	
CN2	USB_TYPEB				USB socket	Through hole	Any		Distrelec: 124164	
C2	120 pF	5 %	50 V		X7R/COG ceramic capacitor	SMD 0603	Any		Any	
C3, C48	100 pF	5 %	50 V		X7R/COG ceramic capacitor	SMD 0603	Any		Any	

Table 7. BOM (continued)

Reference	Part / value	Tolerance %	Voltage current	Watt	Technology information	Package-footprint	Manufacturer	Manufacturer code	RS/Distrelec/ other code	More info
C4, C7, C13, C14, C15, C17, C18, C19, C21, C22, C43, C47, C49, C50, C51, C52, C53, C65, C66, C64, C75, C78, C79, C80, C81, C82, C83, C87, C88, C89	100 nF	10 %	25 V		X7R ceramic capacitor	SMD 0603	Any		Any	
C5, C12, C16, C23, C42	10 µF	20 %	10 V		Y5 V ceramic capacitor	SMD 1206	Any		RS:434-8097	
C6	220 nF X2	20 %	305 Vac		EMI suppression X2 capacitor	Through hole 15 mm lead spacing	EPCOS	B32922A2 224M	RS:497-4129	
C1, C85	10 nF	10 %	25 V		X7R ceramic capacitor	SMD 0603	Any		Any	
C8	2.2 nF	5 %	25 V		COG ceramic capacitor	SMD 0603	Any		Any	
C9	120 pF	5 %	50 V		COG ceramic capacitor	SMD 0603	Any		Any	
C10	10 nF	10 %	50 V		X7R ceramic capacitor	SMD 0805	Any		Any	
C11	15 nF	10 %	50 V		X7R ceramic capacitor	SMD 0805	Any		Any	

Table 7. BOM (continued)

Reference	Part / value	Tolerance %	Voltage current	Watt	Technology information	Package-footprint	Manufacturer	Manufacturer code	RS/Distrelec/ other code	More info
C20	47 µF	10 %	16 V		Tantalum capacitor	SMD 6032-28	Any		RS: 407-0047	
C24, C25	82 µF	20 %	350 V		Aluminum electrolytic capacitor	Through hole 18 mm diameter, 7.5 mm lead spacing	Panasonic	EEUED2V820S	RS: 526-2247	
C26	33 nF X2	10 %	250 Vac		Chip monolithic X2 ceramic capacitors	SMD 2220	MuRata	GA355XR7GB333KY06L	Distrelec: 830079	
C27	1000 µF 16 V ZL	20 %	16 V		Low ESR electrolytic capacitor	Through hole 10 mm diameter, 5 mm lead spacing	Rubycon	16ZL1000M10X20	Distrelec: 801841	
C28	470 µF 16 V ZL	20 %	16 V		Low ESR electrolytic capacitor	Through hole 10 mm diameter, 5 mm lead spacing	Rubycon	16ZL470M10X12.5	Distrelec: 801839	
C29, C30, C38, C67, C68, C69, C70, C71, C77	100 nF	10 %	25 V		X7R ceramic capacitor	SMD 0805	Any		Any	
C31	3.3 µF	20 %	35 V		Aluminum electrolytic capacitor	Through hole	Any		Any	

Table 7. BOM (continued)

Reference	Part / value	Tolerance %	Voltage current	Watt	Technology information	Package-footprint	Manufacturer	Manufacturer code	RS/Distrelec/ other code	More info
C32	330 µF	20 %	16 V		Low ESR electrolytic capacitor	Through hole	Panasonic	EEUFC1C 331	RS: 315-0451	
C33	100 µF 10 V ZL	20 %	16 V		Low ESR electrolytic capacitor	Through hole	Rubycon	16ZLH100 M5x11	Distrelec: 801183	
C34	2.2 nF - Y1	20 %	250 Vac		Y1 ceramic multi-layer capacitors	Through hole	MuRata	DE1E3KX2 22MA5B	Farnell: 3531995	
C35	1 nF	5 %	50 V		COG ceramic capacitor	SMD 0805	Any		Any	
C36	470 nF	10 %	16 V		X7R ceramic capacitor	SMD 0805	Any		Any	
C37	4.7 nF	10 %	50 V		X7R ceramic capacitor	SMD 0805	Any		Any	
C39	4.7 µF	20 %	25 V		electrolytic capacitor	Through hole	Any		Any	
C40	15 pF	5 %	50 V		COG ceramic capacitor	SMD 0805	Any		Any	
C41	4.7 pF	5 %	50 V		COG ceramic capacitor	SMD 0805	Any		Any	
C44, C45	1 nF	10 %	25 V		X7R ceramic capacitor	SMD 0603	Any		Any	
C60, C61	10 pF	5 %	50 V		COG ceramic capacitor	SMD 0603	Any		Any	
C62, C63	22 pF	5 %	50 V		COG ceramic capacitor	SMD 0603	Any		Any	

Table 7. BOM (continued)

Reference	Part / value	Tolerance %	Voltage current	Watt	Technology information	Package-footprint	Manufacturer	Manufacturer code	RS/Distrelec/ other code	More info
C72, C90	4.7 µF	20 %	10 V		Y5V ceramic capacitor	SMD 0805	MuRata	GRM21BF51A475ZA01L	Distrelec: 830046	Any
C76	4.7 nF	10 %	50 V		X7R ceramic capacitor	SMD 0805	Any		Any	
C84	470 nF	10 %	16 V		X7R ceramic capacitor	SMD 0805	Any		Any	
C86	10 µF	10 %	10 V		Tantalum capacitor	SMD 6032-28	Any		RS: 648-0575	
C91, C92	47 nF	10 %	50 V		X7R ceramic capacitor	SMD 0805	Any		Any	
DL1, D14	Green		20 mA		Green LED diode	SMD 0805	Kingbright	KP-2012MGC	RS: 466-3778	
DL2, D15	Yellow		20 mA		Yellow LED diode	SMD 0805	Kingbright	KP-2012SYC	RS: 466-3835	
D13	Red		20 mA		Red LED diode	SMD 0805	Kingbright	KP-2012SRC-PRV	RS: 466-3813	
DZ1	P6KE200A		200 V		Transil diode	Through hole DO-204AC	STMicroelectronics	P6KE200A		ST supply
D1	LL4148		100 V/150 mA		Small signal rectifier	SMD DO213AA	Any		RS: 652-7494	Any
D3, D5	STPS1L30A		30 V/1 A		Low drop power Schottky rectifier	SMD SMA/DO-214AC	STMicroelectronics	STPS1L30A		ST supply

Table 7. BOM (continued)

Reference	Part / value	Tolerance %	Voltage current	Watt	Technology information	Package-footprint	Manufacturer	Manufacturer code	RS/Distrelec/ other code	More info
D4	SM6T15CA				Transil diode	SMD SMB/DO-214AA	STMicroelectronics	SM6T15CA		ST supply
D6	SM6T6V8CA				Transil diode	SMD SMB/DO-214AA	STMicroelectronics	SM6T6V8CA		ST supply
D7, D9	SM4007		1000 V/1 A		Standard rectifier diode	SMD melf/ DO-213AB	Any		RS: 505-4939	
D8	STPS2150		150 V/2 A		Power Schottky rectifier diode	SMD SMA/DO-214AC	STMicroelectronics	STPS2150A		ST supply
D10	STTH108		800 V/1 A		High voltage ultrafast rectifier	Through hole DO-41	STMicroelectronics	STTH108		ST supply
D11	STPS1150		150 V/1 A		Power Schottky rectifier diode	Through hole DO-41	STMicroelectronics	STPS1150		ST supply
D12	STPS1L60		60 V/1 A		Power Schottky rectifier diode	SMD SMA/DO-214AC	STMicroelectronics	STPS1L60A		ST supply
F1	2 A fuse		250 Vac/2 A		Fuse, time delay, 2 A	Through hole radial 5 mm lead spacing	BUSSMANN	BK/ETF 2 A	Farnell:3029979	
FB1, FB2, FB3	BLM21PG331SN1		1500 mA		EMIFIL (Inductor type) chip ferrite bead, Impedance 330 ohm	SMD 0805	MuRata	BLM21PG331SN1	Digi-Key: BLM21PG331SN1D-ND	

Table 7. BOM (continued)

Reference	Part / value	Tolerance %	Voltage current	Watt	Technology information	Package-footprint	Manufacturer	Manufacturer code	RS/Distrelec/ other code	More info
IC1	ST3232EBDR				RS-232 drivers and receivers	SMD SO-16	STMicroelectronics	ST3232EBDR		ST supply
IC2	TFDU4301				IrDA transceiver	SMD	VISHAY semiconductor	TFDU4300-TR1	Farnell: 1469607	
JP11, JP12, JP13, JP14, JP15, JP17, JP18	Close									There are no components mounted
JP4, JP5, JP6, JP7	Close				2 way stripline connector	Through hole 2.54 mm pitch	Any		RS:251-8086	Mount with jumper: RS: 251-8503
JP8	Open				Not mounted	SMD				Not mounted
J2	CON6A				6-way 2row vertical IDC box header	Through hole 2.54 mm pitch	Any		Distrelec: 121631	
J3	CON10AP				10-way 2row vertical IDC box header	Through hole 2.54 mm pitch	Any		RS: 473-8254	
J8	VDD_12 V				2-way horizontal header,5.08 mm pitch	Through hole 5 mm pitch	Tyco Electronics	282815-2	RS: 361-7544	2-way screw terminal RS: 361-7320
J9	MAINS_CON		250 Vac / 2.5 A		Flush-type device plug C8 snap-in	Through hole	Schurter	4300.0099	Distrelec: 110275	Alternative: MULTICOMP, type:JR201S

Table 7. BOM (continued)

Reference	Part / value	Tolerance %	Voltage current	Watt	Technology information	Package-footprint	Manufacturer	Manufacturer code	RS/Distrelec/ other code	More info
J10	CON10				Right-angled IDC boxed header, 10 way 2row	Through hole 2.54 mm pitch 90°	Any		RS: 473-8349	
J11, J20	Jumper				2-way stripline connector	Through hole 2.54 mm pitch	Any		RS: 251-8086	
J12	LCD connector				Mount 2 connectors: 8 way (2x4) double row stripline socket	Through hole 2.54 mm pitch	Any		RS: 488-1730	
J15	JTAG				Right-angled IDC boxed header, 20 way 2row	Through hole 2.54 mm pitch 90°	Any		RS: 473-8377	
J19	RTC_CAL				5-way stripline connector	Through hole 2.54 mm pitch	Any		RS: 251-8121	
J21	SC_CON - NOT FIT	Not mounted			7-way stripline connector	Through hole 2.54 mm pitch			Not mounted	
J22	CON3	Not mounted			3-way top entry socket (strip female)	Through hole 2.54 mm pitch	Any		RS: 488-1724	Not mounted
J23	CON2	Not mounted			2-way top entry socket (strip female)	Through hole 2.54 mm pitch	Any		RS: 488-1724	Not mounted

Table 7. BOM (continued)

Reference	Part / value	Tolerance %	Voltage current	Watt	Technology information	Package-footprint	Manufacturer	Manufacturer code	RS/Distrelec/ other code	More info
J24	ZigBee - CONN1	Not mounted			6-way top entry socket (strip female)	Through hole 2.54 mm pitch	Any		RS: 488-1724	Not mounted
J25	ZigBee - CONN2	Not mounted			6-way top entry socket (strip female)	Through hole 2.54 mm pitch	Any		RS: 488-1724	Not mounted
L1	15 µH	10 %	2.5 A		Power inductor	SMD 10x10mm body size	EPCOS	B82464A4 153K	Farnell: 7429649	
L2	220 µH	10 %	240 mA		Power inductor	SMD 6x6 mm body size	EPCOS	B82462A4 224K	RS: 495-8048	
L3	4.7 µH	20 %	2 A		Power inductor	SMD 6x6 mm body size	EPCOS	B82462G4 472M	Farnell: 7430000	
L4	1 mH	10 %	120 mA		Inductor	SMD 2220	EPCOS	B82442H1 105K	RS: 496-1347	
L5	BEAD		2A		H i g h current (2 A) ferrite chip bead, impedance at 100 MHz: 600 ohm	SMD 0805	KEKITAGAWA	MLB-201209-0600PN	Distrelec: 330138	
NTC1, NTC2	16 Ω	20 %	2.9 A	2.1 W	NTC resistor	Trough hole disc 5 mm lead spacing	EPCOS	B57236S0 160M000	Distrelec: 730576	
Q2	2N7002		60 V/0.2 A		STripFET™ power MOSFET	SMD SOT23-3L	STMicroelectronics	2N7002		

Table 7. BOM (continued)

Reference	Part / value	Tolerance %	Voltage current	Watt	Technology information	Package-footprint	Manufacturer	Manufacturer code	RS/Distrelec/ other code	More info
R1	47 kΩ	1 %		0.1 W	Metal film resistor	SMD 0603	Any		Any	
R2, R3, R5, R6	10 kΩ	1 %		1 W	Professional MELF resistors	SMD MMB 0207	Vishay		Distrelec: 710082	
R4	120 Ω	1 %		0.1 W	Metal film resistor	SMD 0603	Any		Any	
R7	10 kΩ	1 %		0.1 W	Metal film resistor	SMD 0603	Any		Any	
R8	39 kΩ	1 %		0.1 W	Metal film resistor	SMD 0603	Any		Any	
R9	330 Ω	1 %		0.1 W	Metal film resistor	SMD 0603	Any		Any	
R11, R18	47 kΩ	1 %		0.1 W	Metal film resistor	SMD 0603	Any		Any	
R12	1 kΩ	1 %		0.1 W	Metal film resistor	SMD 0603	Any		Any	
R13	5.1 kΩ	1 %		0.1 W	Metal film resistor	SMD 0603	Any		Any	
R14	24 kΩ	1 %		0.1 W	Metal film resistor	SMD 0603	Any		Any	
R17	150 Ω	1 %		0.1 W	Metal film resistor	SMD 0603	Any		Any	

Table 7. BOM (continued)

Reference	Part / value	Tolerance %	Voltage current	Watt	Technology information	Package-footprint	Manufacturer	Manufacturer code	RS/Distrelec/ other code	More info
R10, R15, R19, R20, R21, R23, R24, R25, R26, R27, R28, R29, R30, R31, R32, R33, R34, R58, R90, R71, R72, R73, R74, R88, R89	4.7 kΩ	1 %		0.1 W	Metal film resistor	SMD 0603	Any		Any	
R22, R61	1 kΩ	1 %		0.1 W	Metal film resistor	SMD 0603	Any		Any	
R35, R37	6.8 MΩ	5 %		0.25 W	Metal film resistor	SMD 1206	Any		Any	
R36	2.5 kΩ	5 %		0.25 W	Metal film resistor	SMD 1206	Any		Any	
R38	33 kΩ	1 %		0.25 W	Metal film resistor	SMD 1206	Any		Any	
R39	10 Ω	5 %		0.25 W	Metal film resistor	SMD 1206	Any		Any	
R40	Not mounted			0.25 W	Metal film resistor	SMD 1206				
R41	10 kΩ	1 %		0.25 W	Metal film resistor	SMD 1206	Any		Any	
R42	75 kΩ	1 %		0.25 W	Metal film resistor	SMD 1206	Any		Any	
R43	15 Ω	1 %		0.25 W	Mini-MELF resistors	SMD 1206	Any	Vishay	Distrelec:713 030	

Table 7. BOM (continued)

Reference	Part / value	Tolerance %	Voltage current	Watt	Technology information	Package-footprint	Manufacturer	Manufacturer code	RS/Distrelec/ other code	More info
R44	1.2 Ω	1 %		0.25 W	Mini-MELF resistors	SMD 1206	Any	Vishay	Distrelec: 713004	
R45	8.2 kΩ	1 %		0.25 W	Metal film resistor	SMD 1206	Any		Any	
R46	1.5 kΩ	5 %		0.25 W	Metal film resistor	SMD 1206	Any		Any	
R47	330 Ω	5 %		0.25 W	Metal film resistor	SMD 1206	Any		Any	
R48, R49, R50, R51, R53, R54, R55, R57, R75	10 kΩ	1 %		0.1 W	Metal film resistor	SMD 0603	Any		Any	
R52	Not mounted					SMD 0603				Not mounted
R56	1 MΩ	1 %		0.1 W	Metal film resistor	SMD 0603	Any		Any	
R59, R60, R80, R81, R82, R83, R84, R85, R86, R87, R91	0	1 %		0.1 W	Metal film resistor	SMD 0603	Any		Any	
R62, R63	0 - not fit					SMD 0603				Not mounted
R64	5 Ω	1 %		0.1 W	Metal film resistor	SMD 0603	Any		Any	
R65	47 Ω	1 %		0.1 W	Metal film resistor	SMD 0603	Any		Any	
R66, R67	22 Ω	1 %		0.125 W	Metal film resistor	SMD 0805	Any		Any	
R68	1 MΩ	5 %		0.125 W	Metal film resistor	SMD 0805	Any		Any	

Table 7. BOM (continued)

Reference	Part / value	Tolerance %	Voltage current	Watt	Technology information	Package-footprint	Manufacturer	Manufacturer code	RS/Distrelec/ other code	More info
R69	1.5 kΩ	5 %		0.125 W	Metal film resistor	SMD 0805	Any		Any	
R70	100 Ω	1 %		0.1 W	Metal film resistor	SMD 0603	Any		Any	
R76, R77, R78	300 Ω	5 %		0.125 W	Metal film resistor	SMD 0805	Any		Any	
R79	47 Ω	1 %		0.1 W	Metal film resistor	SMD 0603	Any		Any	
RV1	S14K510	10 %	510 Vac		Disk-shaped metal-oxide varistor	Through hole	EPCOS	B72214S0 511K101	Distrelec: 730933	
SW1, SW4, S1	ST7580 reset				Tactile switch 100 gF	Through hole 6X6 mm 5 mm height	Any		RS:378-6410	
SW3	E0				3-way stripline connector	Through hole 2.54 mm pitch	Any		RS: 251-8092	
SW5	E1				3-way stripline connector	Through hole 2.54 mm pitch	Any		RS: 251-8092	
SW6	E2				3-way stripline connector	Through hole 2.54 mm pitch	Any		RS: 251-8092	
SW7	BOOT0				3-way stripline connector	Through hole 2.54mm pitch	Any		RS: 251-8092	

Table 7. BOM (continued)

Reference	Part / value	Tolerance %	Voltage current	Watt	Technology information	Package-footprint	Manufacturer	Manufacturer code	RS/Distrelec/ other code	More info
SW9	BOOT1				3-way stripline connector	Through hole 2.54 mm pitch	Any		RS: 251-8092	
SW10, SW12, SW16, SW17, SW18	Switch				3-way stripline connector	Through hole 2.54 mm pitch	Any		RS: 251-8092	
SW11, SW13, SW14, SW15, SW19, SW20, SW21, SW22, SW23	Jumper				3-way stripline connector	Through hole 2.54 mm pitch	Any		RS: 251-8092	
TP1	CL				Loop terminal assembly, 1 mm hole	Through hole			RS: 101-2391	Test point
TP2	ZC_IN				Loop terminal assembly, 1 mm hole	Through hole			RS: 101-2391	
TP3	PA_IN-				Loop terminal assembly, 1 mm hole	Through hole			RS: 101-2391	
TP4	PA_IN+				Loop terminal assembly, 1 mm hole	Through hole			RS: 101-2391	
TP5	TX_OUT				Loop terminal assembly, 1 mm hole	Through hole			RS: 101-2391	
TP6	PA_OUT				Loop terminal assembly, 1 mm hole	Through hole			RS: 101-2391	

Table 7. BOM (continued)

Reference	Part / value	Tolerance %	Voltage current	Watt	Technology information	Package-footprint	Manufacturer	Manufacturer code	RS/Distrelec/ other code	More info
TP7	VDDIO				Loop terminal assembly, 1 mm hole	Through hole			RS: 101-2391	
TP8	VDD				Loop terminal assembly, 1 mm hole	Through hole			RS: 101-2391	
TP9	VDD_PLL				Loop terminal assembly, 1 mm hole	Through hole			RS: 101-2391	
TP10	VCC				Loop terminal assembly, 1 mm hole	Through hole			RS: 101-2391	
TP11	VCCA				Loop terminal assembly, 1 mm hole	Through hole			RS: 101-2391	
TP12	RX_IN				Loop terminal assembly, 1 mm hole	Through hole			RS: 101-2391	
T1	VAC 5024X044				Signal-transformer	SMD	VAC VACUUMSCHMELZE	T60403-K5024-X044		
T2	TDK - REV.C			6 W	General transformers	Through hole	TDK	SRW16ES		ST supply
U1	ST7580				FSK, N-PSK multi-mode power line networking system-on-chip	SMD QFN-48	STMicroelectronics	ST7580		ST supply

Table 7. BOM (continued)

Reference	Part / value	Tolerance %	Voltage current	Watt	Technology information	Package-footprint	Manufacturer	Manufacturer code	RS/Distrelec/ other code	More info
U2	M25P10-A				1 Mbit, serial Flash memory, 50 MHz SPI bus interface	SMD SO8	NUMONIX	M25P10-AVMN6P	RS: 608-5647	
U3	LF33AB		3.3 V		Very low drop voltage regulators with inhibit	SMD DPAK	STMicroelectronics	LF33ABDT-TR		ST supply
U4	Altair04-900									ST supply
U5	STM32F103 VET6				32-bit MCU	SMD LQFP100	STMicroelectronics	STM32F103VET6		ST supply
U6	M24128-BWMN6P				128-Kbit, 64-Kbit and 32-Kbit serial I²C bus EEPROM	SMD SO8	STMicroelectronics	M24128-BWMN6TP		ST supply
U7	USBLC6-2P6 - not fit			Very low capacitance ESD protection	SMD SOT-666	STMicroelectronics	USBLC6-2P6	Not mounted	ST supply	
U8	MT008-A				Joystick					ST supply
U9	TSM0505S	10 %	5 V/5 V 200 mA		DC/DC converter	SMD SOIC-14			RS: 510-5431	
U10	IL712S-1E		2500 Vrms		Bi-directional digi isolator	SMD MSOP-8	NVE	IL712S-1E	RS: 418-436	

Table 7. BOM (continued)

Reference	Part / value	Tolerance %	Voltage current	Watt	Technology information	Package-footprint	Manufacturer	Manufacturer code	RS/Distrelec/ other code	More info
V1	Battery holder				PCB mount coin cell holder,12 mm	Through hole	Keystone	500	RS: 430-653	CR1220 lithium coin cell (RS: 597-172)
Y1,Y3	8 MHz	30 ppm			8 MHz crystal	Through hole HC49S	Any		RS: 672-0268	
Y2	32.768 kHz	20 ppm			32.768 kHz crystal		Any		RS: 547-6979	Mount this crystal in horizontal position
ISO1	TLP 421				Optocoupler	Through hole DIP4	TOSHIBA	TLP 421	Distrelec: 631515	
Spacer					5 mm metal spacer with inner and outer threads	Through hole	Any		Distrelec: 341130	
Spacer					35 mm metal spacer with RH and LH internal threads	Through hole	Any		Distrelec: 341077	
Washers					Washer M3		Any		RS: 189-620	
Nuts					Nut M3		Any		RS: 483-0502	

5 Schematics

Figure 8. Top

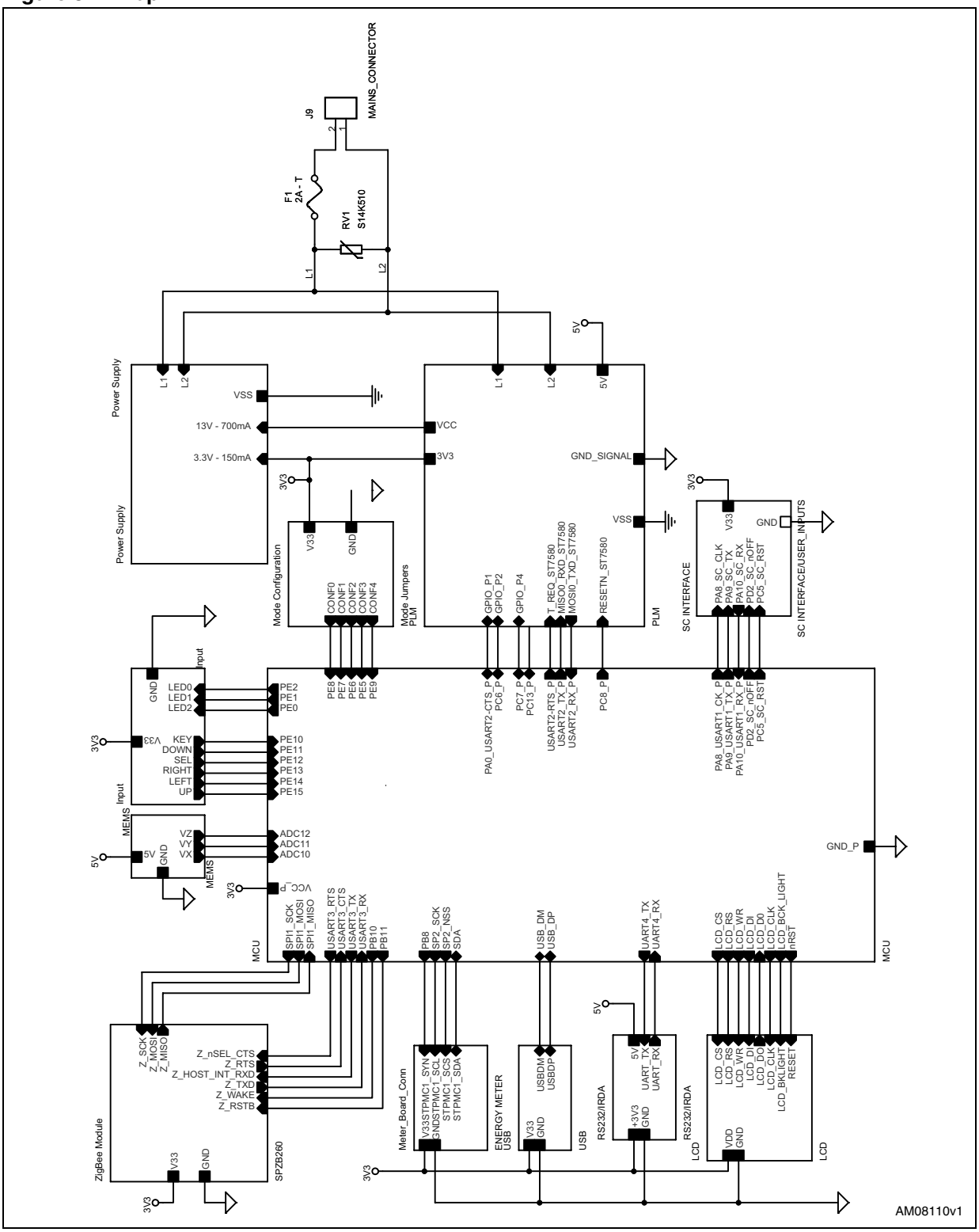


Figure 9. Metrology board connector

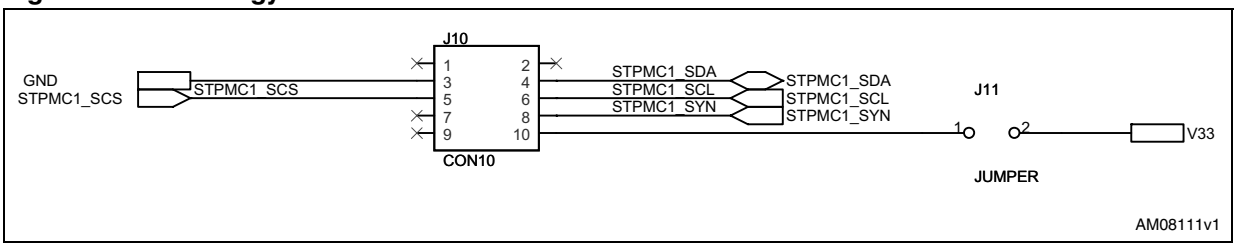


Figure 10. User interface

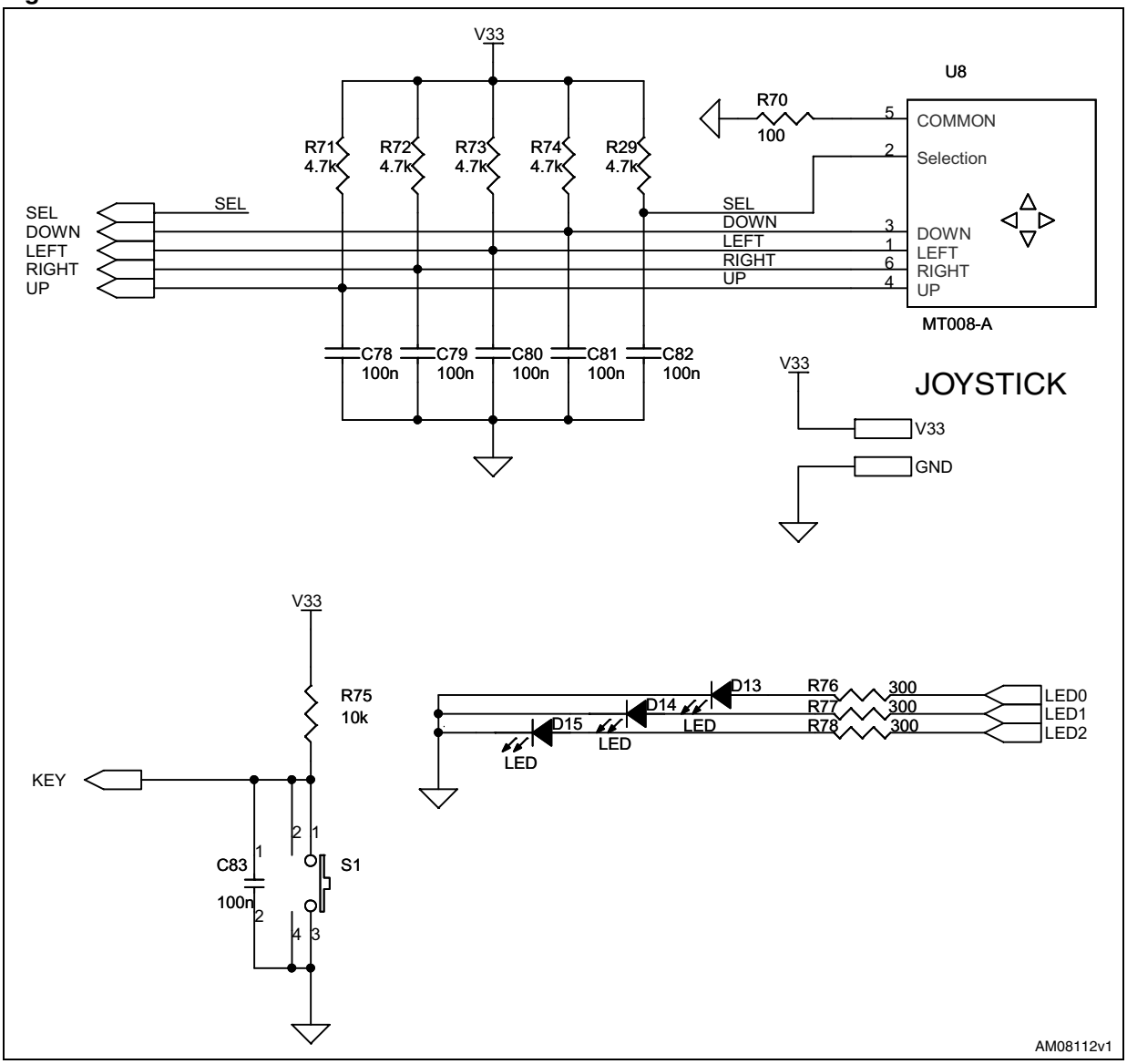


Figure 11. LCD connector section

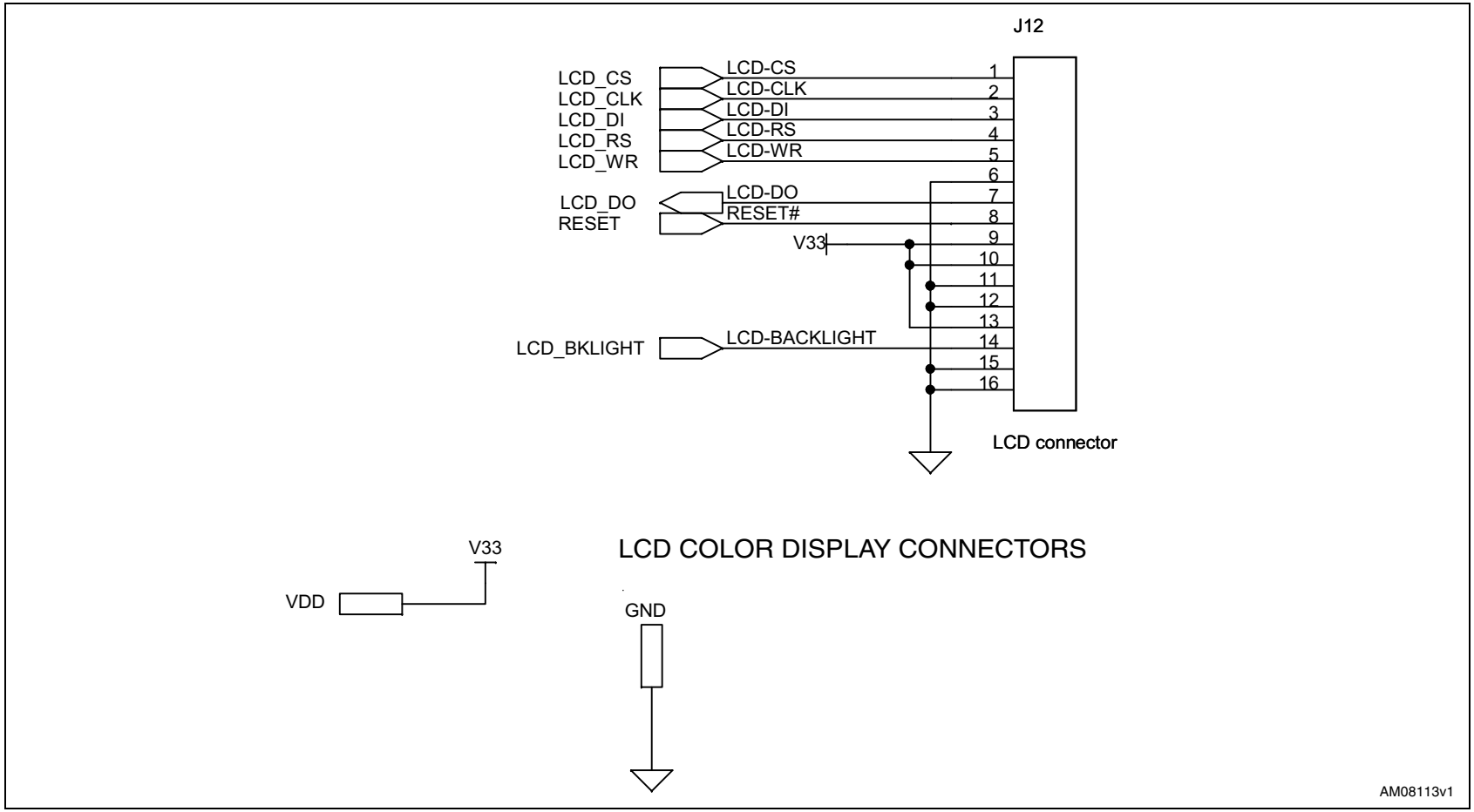


Figure 12. MCU schematic

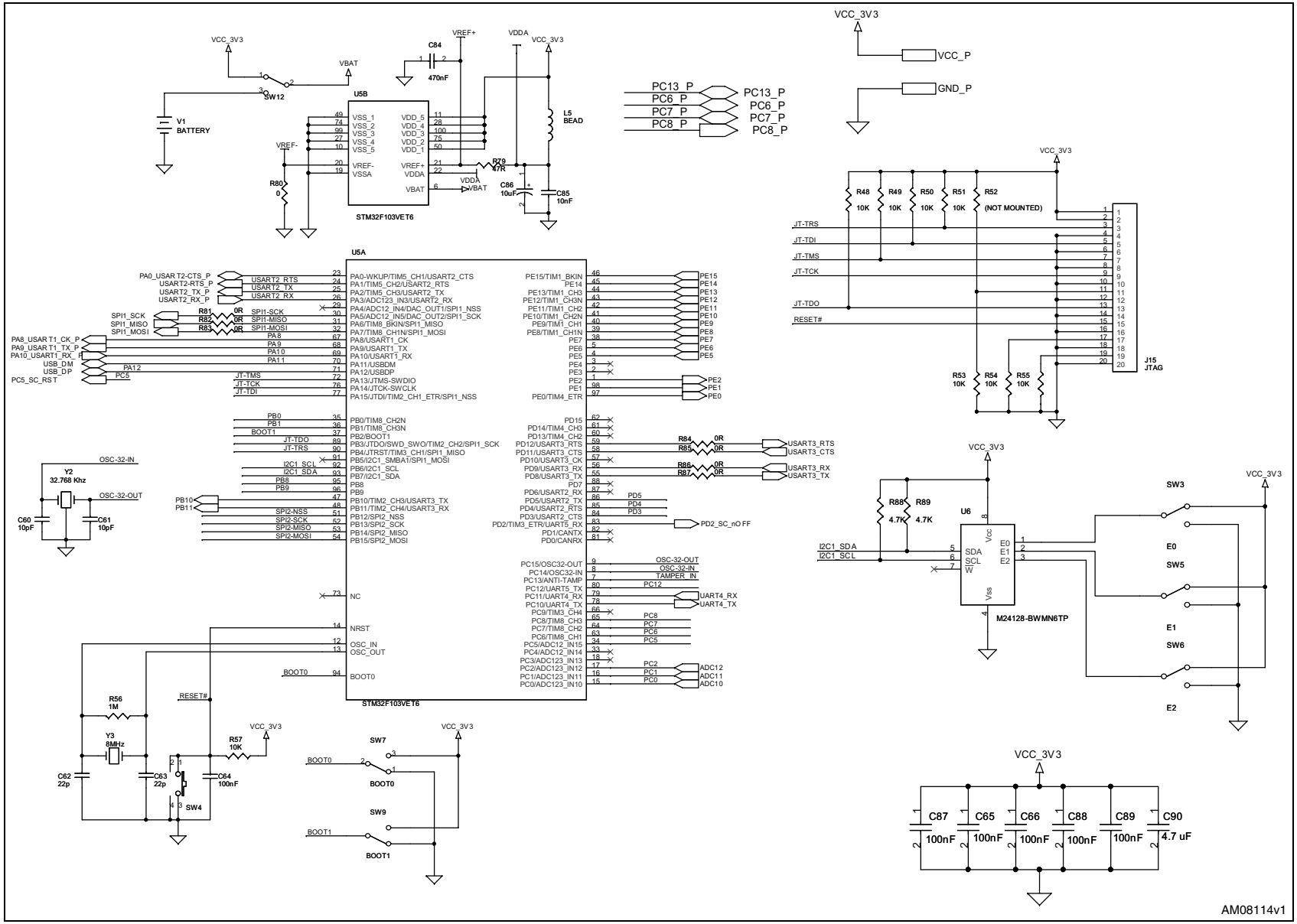


Figure 13. RTC calibration, meter and LCD level

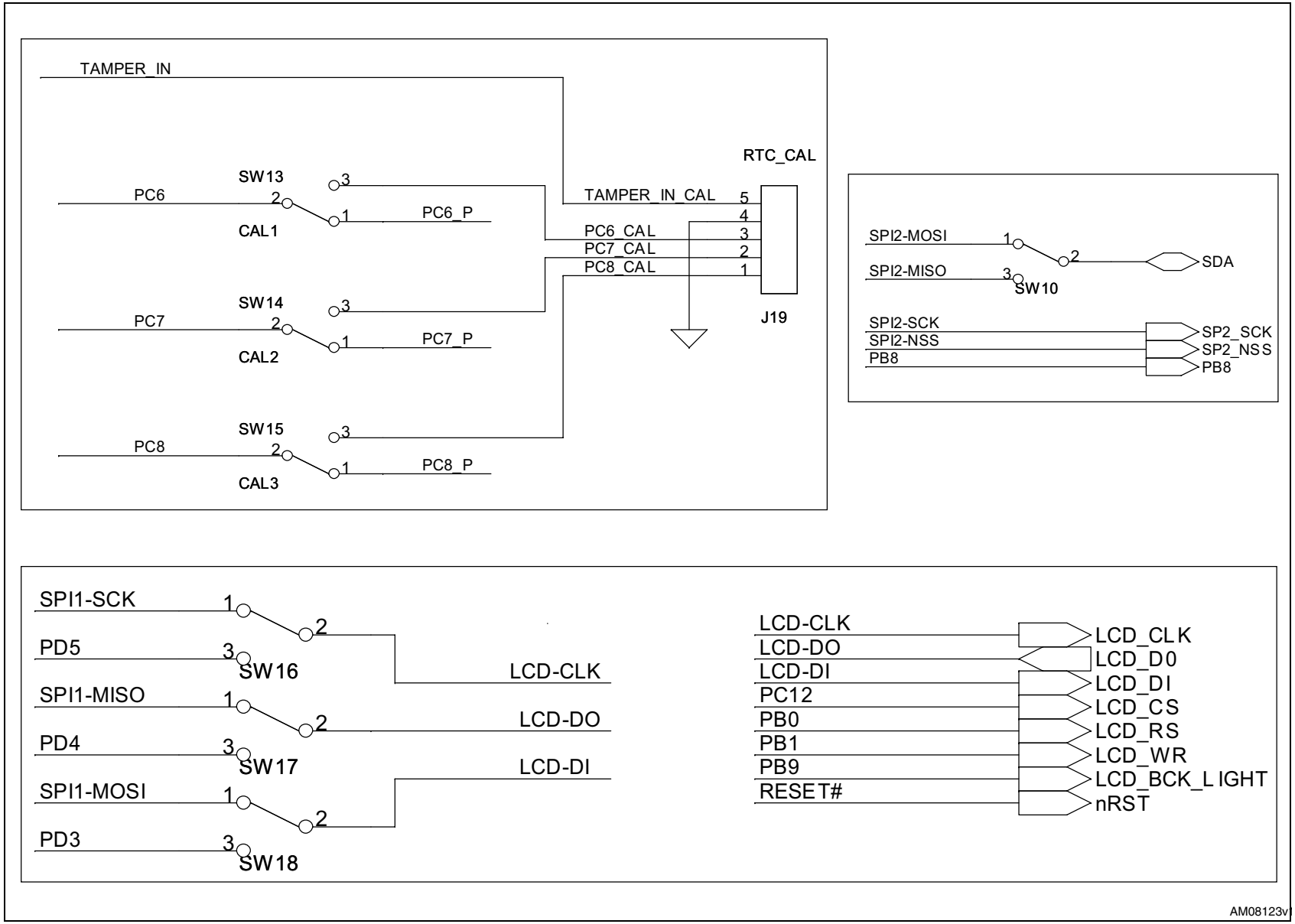


Figure 14. MEMS module connector

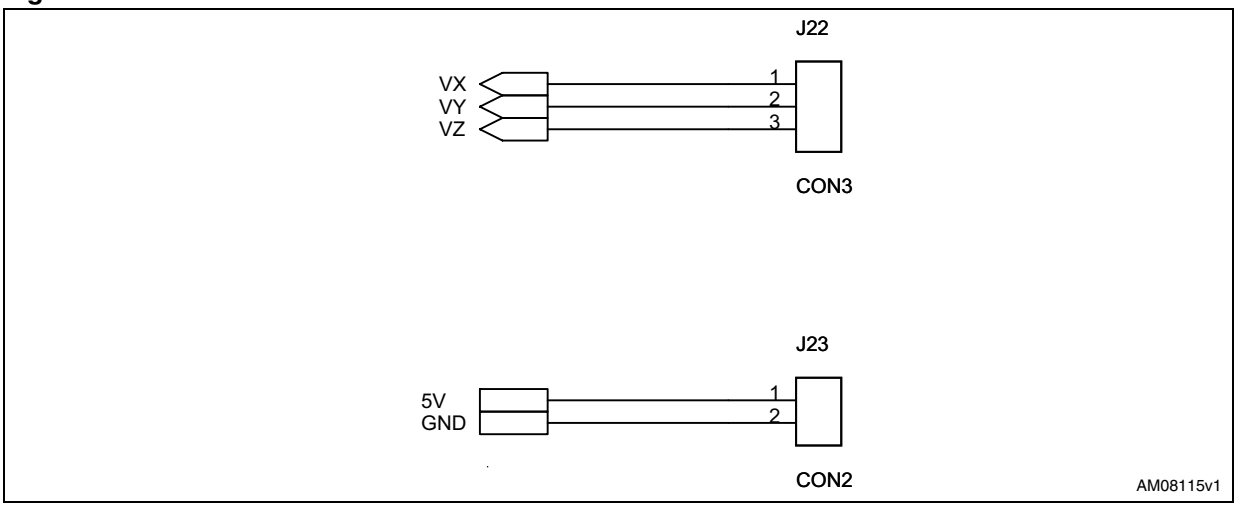


Figure 15. General purpose configuration jumpers

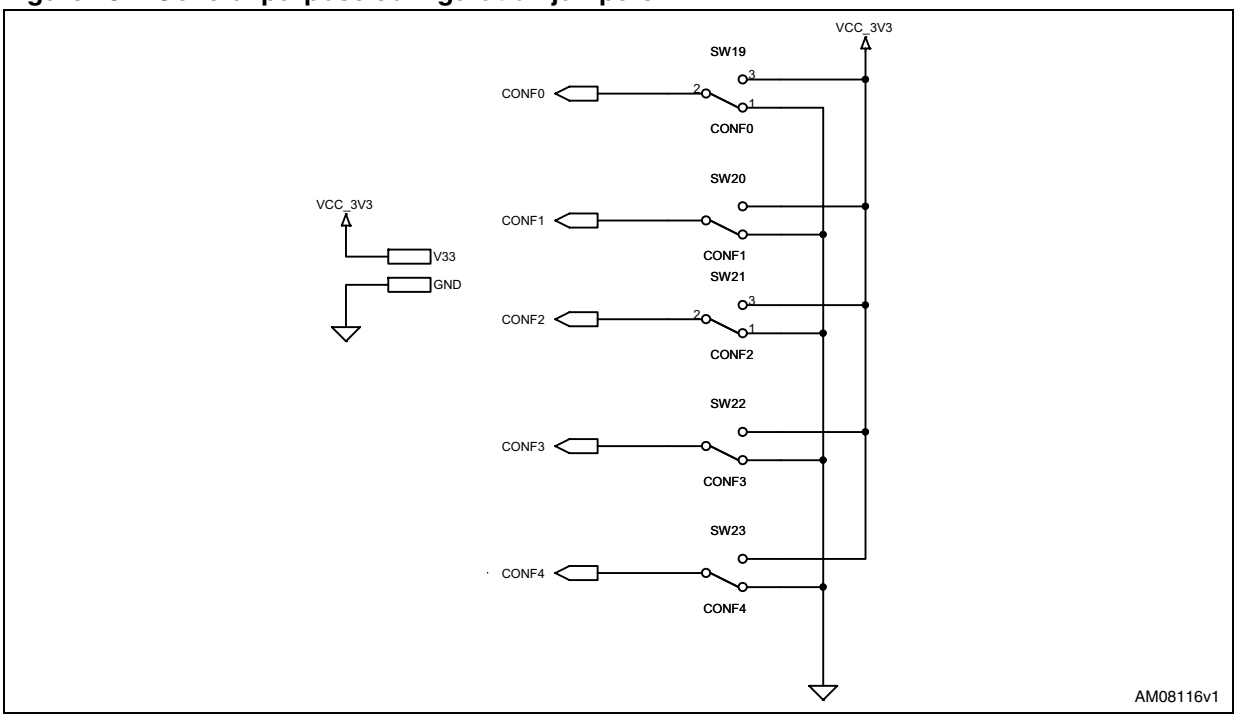


Figure 16. Power line modem

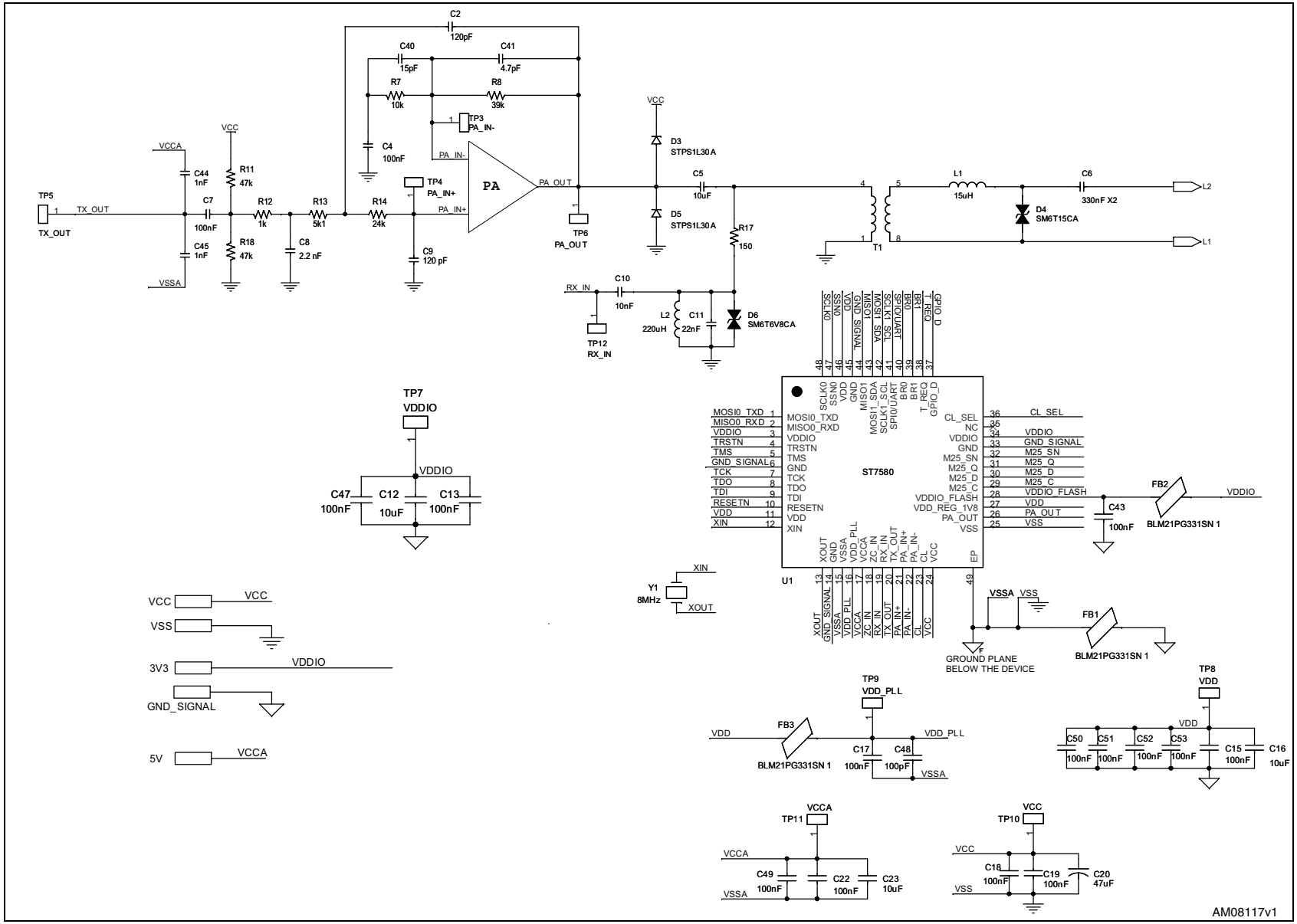


Figure 17. System JTAG connector, ST7580UART interface, and 8051 program flash memory

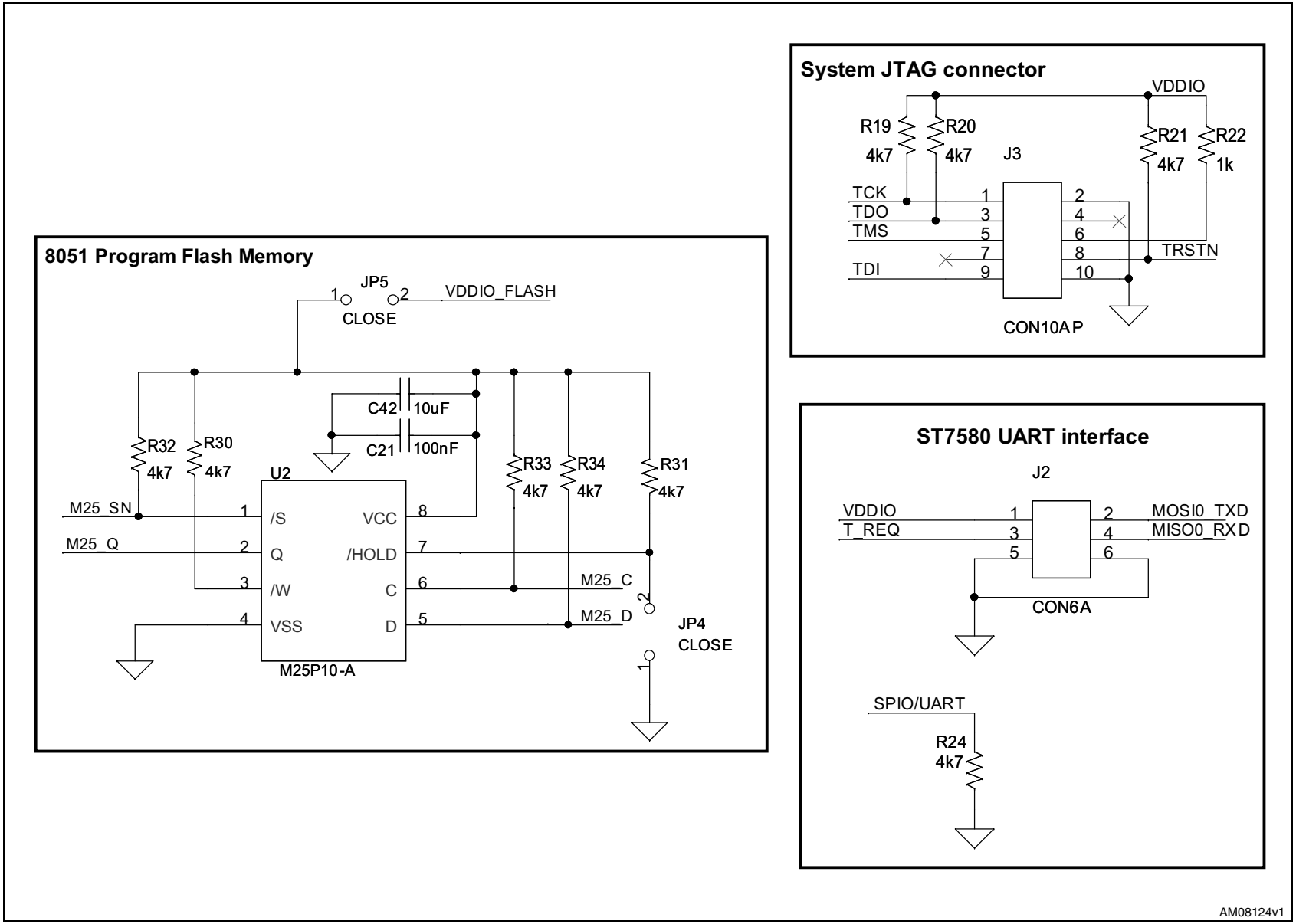


Figure 18. Non-isolated zero-crossing, ST7580 reset button, current limit setting, and microcontroller connection

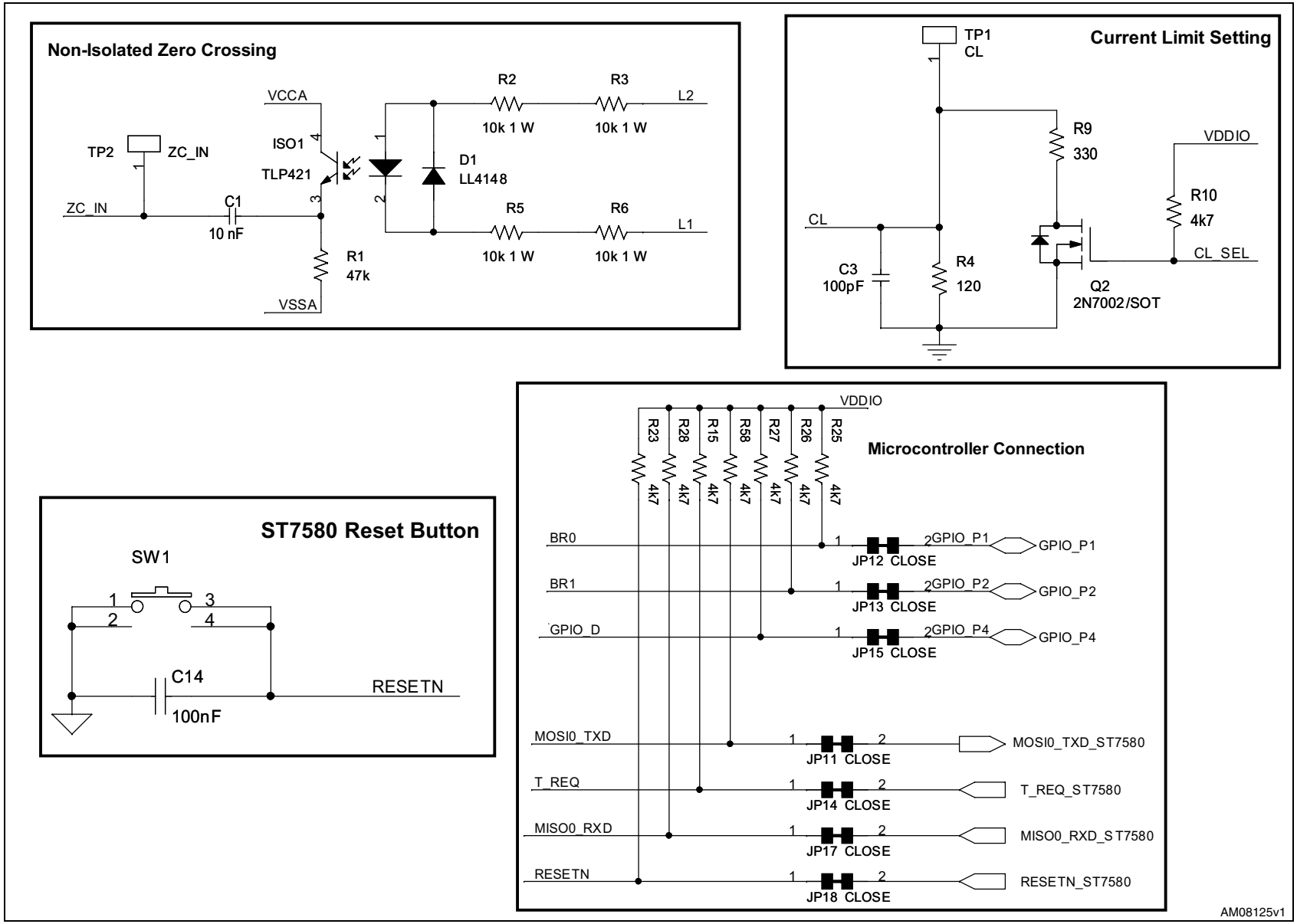


Figure 19. Power supply (part 1)

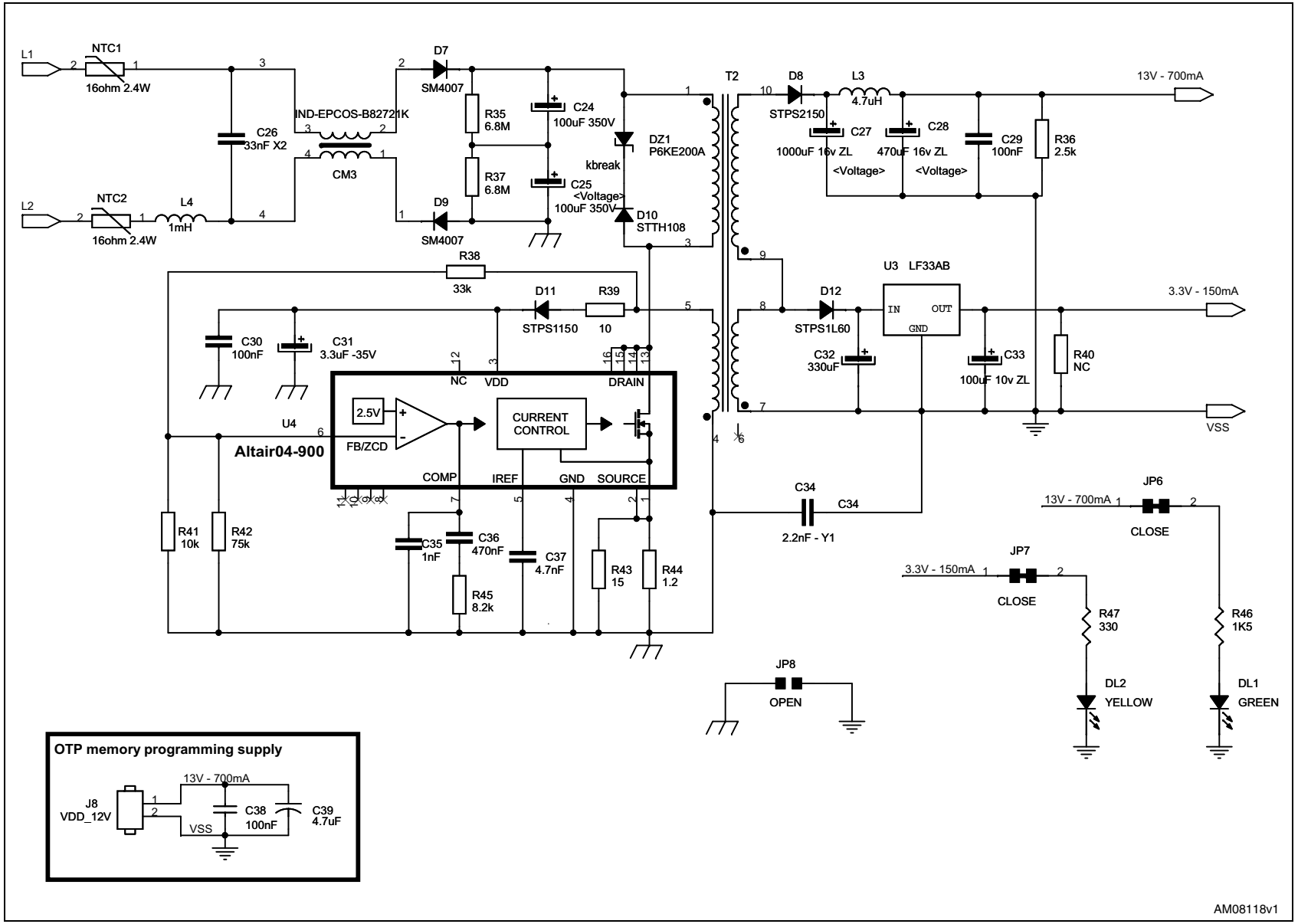


Figure 20. Power supply (part 2)

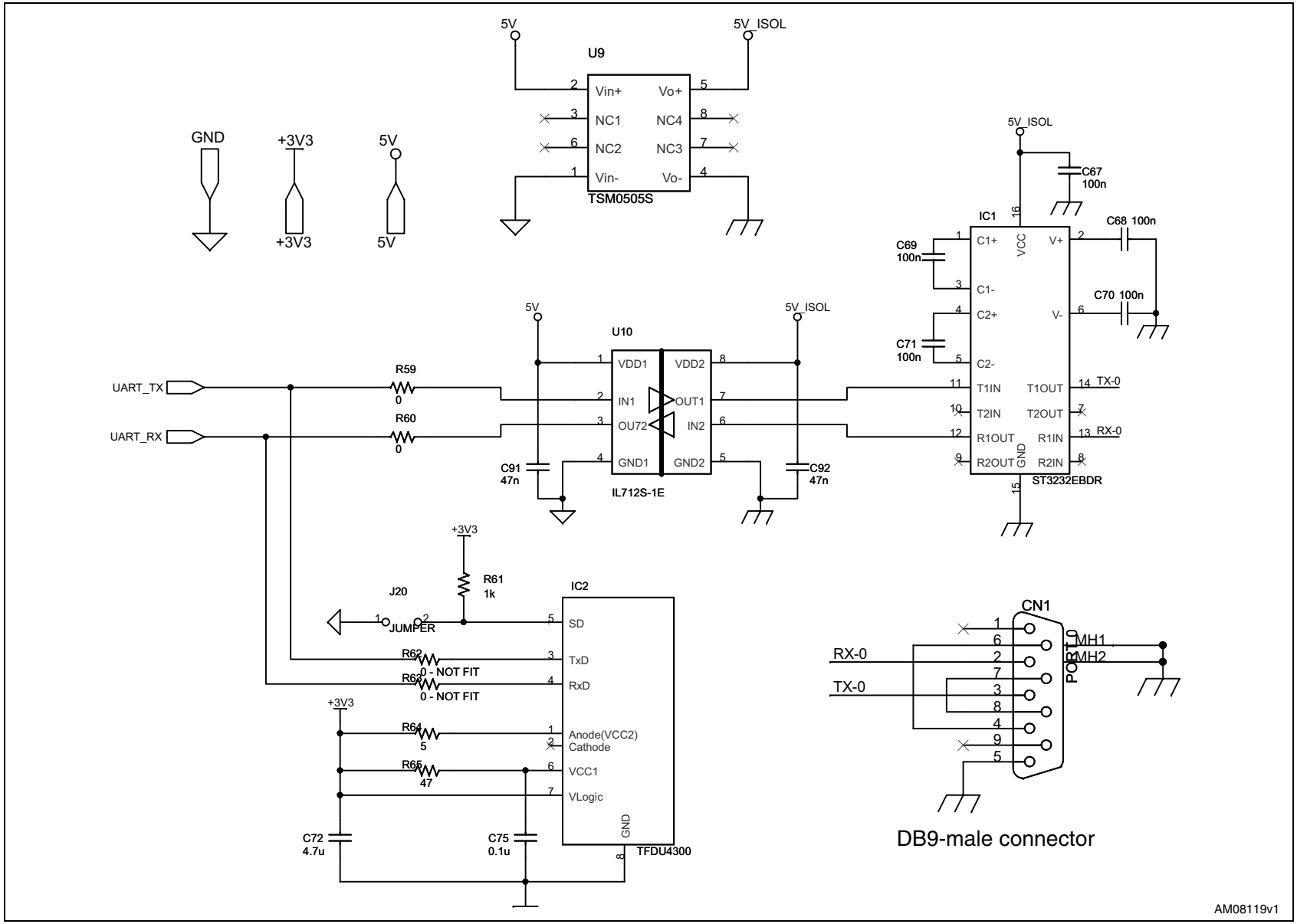


Figure 21. Power supply (part 3)

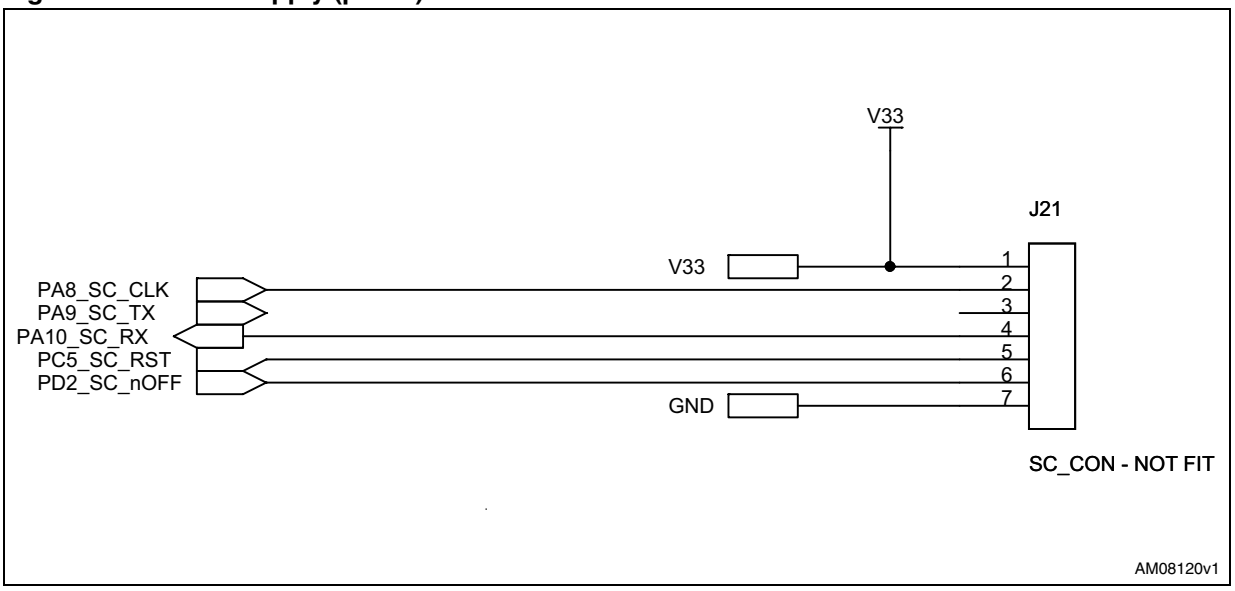


Figure 22. ZigBee module connector

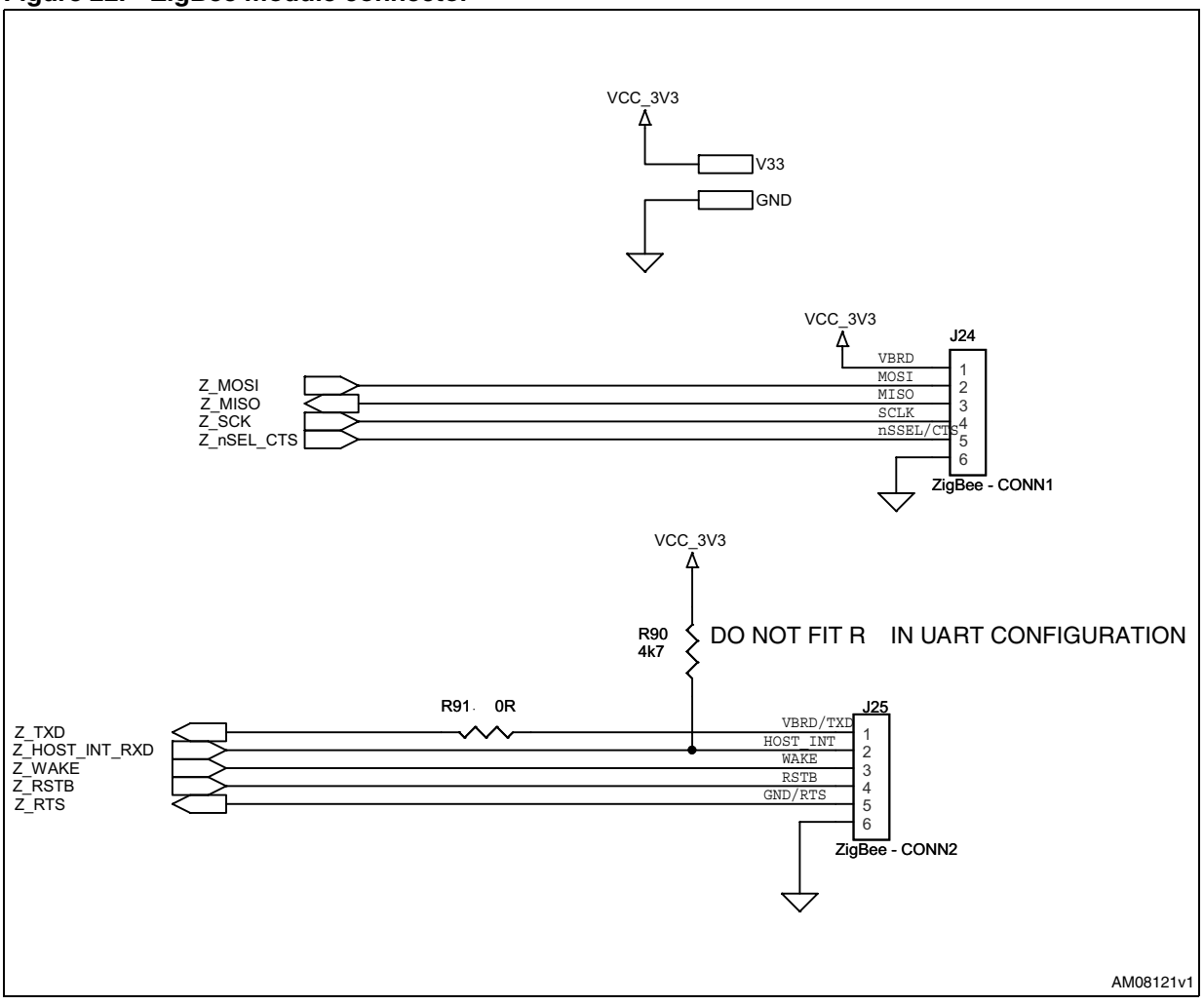
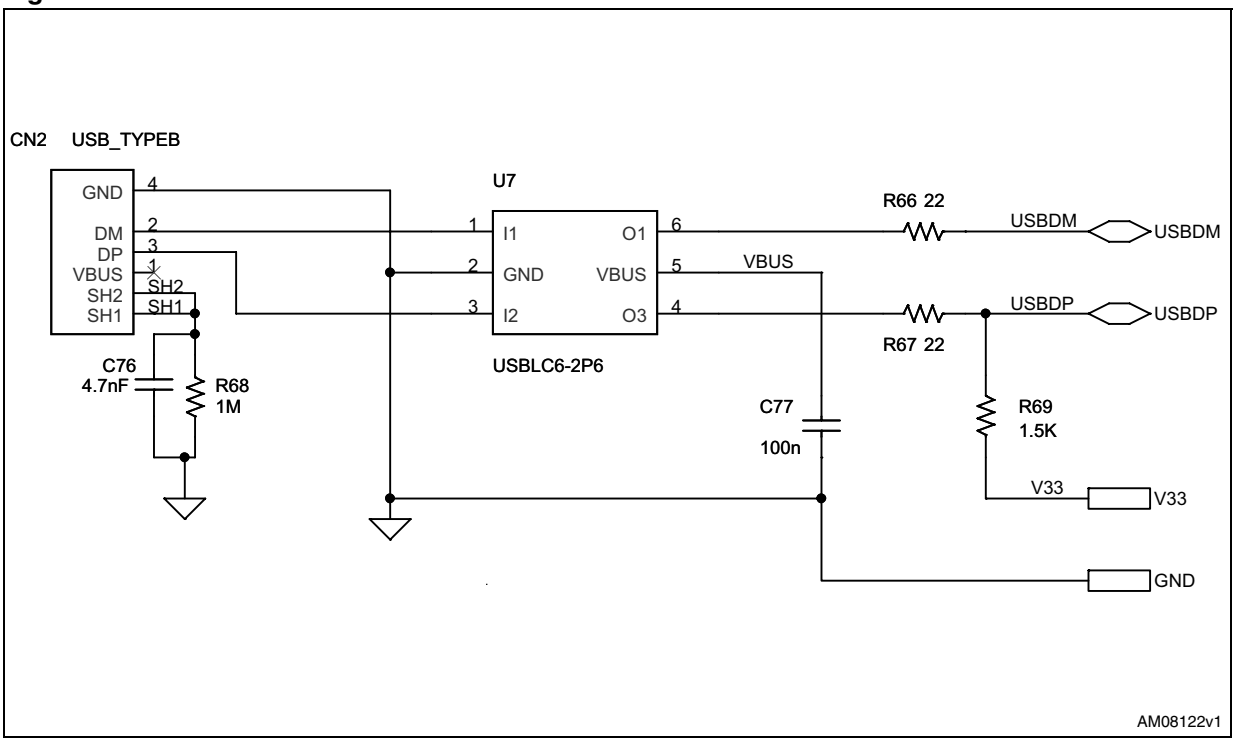


Figure 23. USB connector



6 References

- STM32F103VE datasheet
- RM0008 reference manual
- STM32F10xFWLib 3.0.0 help file
- FreeRTOS official web-site www.freertos.org
- UM0997 user manual
- STPMC1 datasheet
- UM0746 user manual
- ST7580 data brief

7 Revision history

Table 8. Document revision history

Date	Revision	Changes
13-Jan-2011	1	Initial release.
10-Nov-2011	2	Updated: title of *Figure 5* and *6*

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